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Delineation of Groundwater Utility Status in Nashik District Using GIS & RS

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Abstract:

Nashik District, a major agricultural and industrial hub in Maharashtra, faces increasing pressure on its groundwater resources due to rapid urbanization and erratic rainfall patterns. Groundwater is one of the most important natural resources for drinking, agriculture, and industrial activities. In semi-arid regions such as parts of Maharashtra, groundwater availability is uneven due to geological structure, rainfall variability, and land-use patterns. The present study aims to identify and delineate Groundwater Potential Zones (GWPZ) and assess their utility status using Geographic Information System (GIS) and Remote Sensing (RS) techniques. Various thematic layers such as geology, geomorphology, slope, drainage density, rainfall, soil type, lineament density, and land use/land cover were integrated in a GIS environment. Weighted overlay analysis was applied to generate groundwater potential zones. The results classified the district into different groundwater utility zones such as poor, moderate, good, and very good potential areas. The resulting maps will categorize the district into zones of high, moderate, and poor groundwater availability. The study highlights the importance of geospatial technologies in groundwater resource assessment and sustainable water resource management. This study also help as a scientific baseline for local authorities to implement sustainable water management and artificial recharge strategies in water-stressed regions of the district.

Keywords: Ground Water Potential, Weighted Overlay Analysis, Resource Management

Introduction:

Water is considered an elixir of life, without it, it isn't easy to imagine life on Earth. Rainfall is the primary source of water on the earth's surface. After the earth's surface receives rainfall, either it is deported to water bodies through surface runoff or it seeps into the ground. Based on these specialties of water movement, water can be broadly divided into two types. The first one is surface water, which includes streams of different sizes whether they are big or small, and the second one is groundwater. After water seeps into the ground, it flows through unsaturated zones and ultimately reaches the water table. A water table is an imaginary surface from where the ground beneath is saturated Suhag, R. (2016). Groundwater is a dependable source of freshwater, especially in regions where surface water is limited or seasonal. In India, increasing population, agricultural intensification, and industrial growth have placed tremendous pressure on groundwater resources.

It is the tradition in the drought prone areas of the Maharashtra state to use well water as a protective irrigation in the monsoon and post monsoon season (Bhagat, 2002, Bhagat 2004). The wells have prime role in this support irrigation system for cash crops in the drought prone areas. After, planners have suggested maximum use of groundwater potentials in 70s (F.F.C. 1973), these areas are facing acute problems of water table fluctuations and number of dry wells increasing in last three decades.

Nashik district is an agriculturally important region, known for horticulture and vineyards, which depend heavily on groundwater irrigation. However, uneven rainfall distribution, Deccan Trap basalt geology, and

excessive extraction have led to declining groundwater levels in several parts of the district. Geographic Information System (GIS) and Remote Sensing (RS) provide efficient tools for spatial analysis and mapping of groundwater resources. By integrating multi-criteria data, these technologies help in identifying groundwater potential and utility zones, which is essential for sustainable resource planning.

Study Area:

Nashik district is located in the northern western part of the State. It is the third largest district in Maharashtra in terms of Population of 61,09,052 and occupies an area of 15,582 square kilometres in the north Maharashtra region. It is bounded by Dhule district to the north, Jalgaon district to the east, Aurangabad district to the southeast, Ahmednagar district to the south, Thane district to the southwest, Valsad and Navsari districts of Gujarat to the west, and Dangs district to the northwest. Nashik district is one of the six districts of Khandesh Region of Maharashtra State.

It lies between 19°35' and 20°50' north latitude and between 73°16' and 74°56' east longitude and falls in parts of Survey of India degree sheets 46-H, 46-L and 47-E and 47-I. The district has a geographical area of 15,582 sq. km.

The district headquarters is located at Nashik Town. For administrative purpose four divisions have been formed namely Nashik, Niphad, Malegaon and Peth. The district is further subdivided in to 15 Blocks viz., Balgam Satana, Chandwad, Deola, Dindori, Igatpuri, Kalwan, Malegaon, Nandgaon, Nashik, Niphad, Peth, Sinnar, Surgana, Trambakeshwar and Yeola.

It has a total population of 61,09,052 as per 2011 census. The district has 15 towns/blocks and 1930 villages. The major part of the district comes under Godavari and Tapi basin. Godavari originates from Brahmagiri mountain range is on the Western Ghats of Nashik district of Maharashtra state.

The extreme west of the Nashik district in the close proximity of the Western Ghats the rainfall is very much heavier than in the rest of the district. The western track of the district is covered by a rugged terrain and the monsoon wind carrying moisture first meets these hill tops where it deposits much of its water, Surgana, Peint, Triambakeshwar and Igatpuri come under this track. Igatpuri receives the highest average rainfall. On the other hand, it dwindles in the central and eastern sectors of the district. The central part comprising Nashik, Kalvan, Baglan, Dindori, Deolaand Chandvad Blocks gets moderate rainfall. In the plateau region to the east of Western Ghats covering Sinnar, Niphad, Nandgaon, Malegaon and Yeola Blocks receive scanty and usually deficient rainfall. The average annual rainfall in the district is 1,034.13 mm.

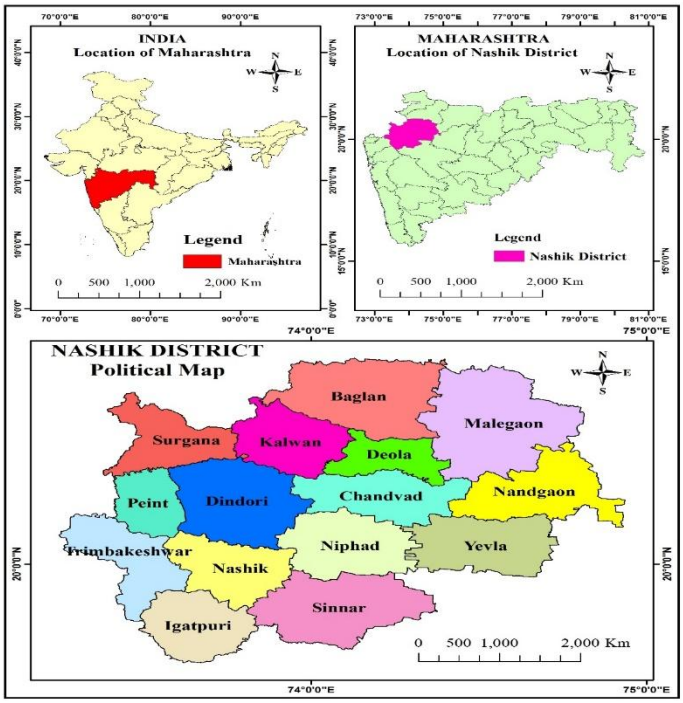

Fig: 1 Geographical Location of the Study Area

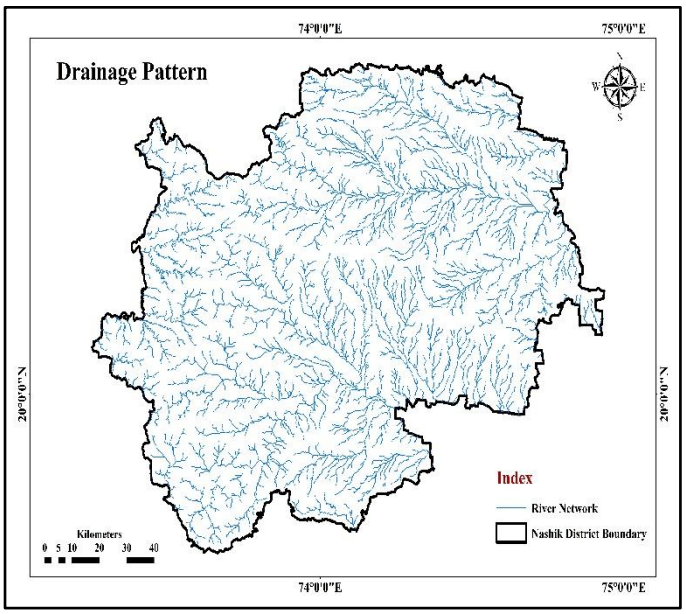

Fig: 3 Drainage System

Objectives:

The paper is mainly devoted to investigate the utility status of groundwater. The present mainly used following objectives.

1. To investigate levels of ground water depth and fluctuations. It is useful to delineate groundwater utility status areas
2. To classify the ground water areas depicting utility status.

Data base and software used:

The secondary data has been used for this study. Annually depth of water for the period of 25 years i.e. from 1998 to 2023 has been procured from the records in the central ground water board government of India ministry of Jal Shakti department of water resources. This information is based on monthly observations of about 61 notified wells located within the district. This dataset were compiled, merged and loaded in the GIS software, ArcMap 10.8. ArcMap is a Windows-based, integrated GIS and Remote Sensing application license source software (www.esri.com, developed by Environmental Systems Research Institute, and consists of display of raster and multiple vector maps in map windows, image processing facilities, GIS analysis tools etc.

Methodology:

The delineation process of GUSA in this study can be discussed into four steps: Statistical analysis for attribute data by using conventional statistical methods. Preparation of attribute maps depicting 1] groundwater depth and 2] fluctuations Preparation of distribution maps for both groundwater depth and fluctuations separately. Combining the map showing groundwater depth with map indicating fluctuations by the cross operation in ArcMap. Suitable conventional statistical techniques are used for the data analysis, viz. Mean, standard deviation and coefficient of variance. Coefficient of variance, which is ratio of mean to standard deviation, has been used as the indicator of water table fluctuations. The high value of variance indicating the high fluctuations in water table and low indicates stability.

The attribute maps are prepared using attribute information (depth and coefficient of variance) of notified wells loaded in the attached table files in GIS. The information showing on the attribute maps have been interpolated on the maps using ‘interpolation’ operator with ‘moving average’ method in ILWIS 3.4 for groundwater depth and fluctuations separately. The values depicted on distribution maps have been broadly

classified in to three classes e.g. low (L), medium (M) and high (H) using slicing operation in ILWIS 3.4 (figure 4 and 5) for theoretical comparison and practical purpose. Groundwater depth is indicating level of exploitation and fluctuations are instability and irrigation insecurity. With this understanding, finally, GUSA have been delineated based on groundwater depth and level of fluctuations. For this intent, maps showing groundwater depth (figure 4) and fluctuations (figure 5) have been combined using the 'cross' operation in ILWIS. In this operation nine GUSA (3 classes of depth X 3 for fluctuations) have been identified. Out of nine classes, similar and insignificant classes have been merged and finally, five GUSA have been identified for application purpose. First letters in the class name (MH, HL, MM, LM and ML) is indicating groundwater depth and second instability (figure 6) according to attribute map classification (figure 4 and 5).

Results and Discussions:

Distribution of groundwater depth:

Distribution of groundwater depth is varied according to topography, rainfall (Subrahmanyam, 1983), drainage system and cropping pattern (Chaudhari et al 1996) in the district (Bhagat 2005). About 50 per cent of TGA (table 1) located in northeast and east part of district having less rainfall (figure no. 4) is observed groundwater at medium as well as low depth (figure 4). Area (48 per cent) having high rainfall in western part of the district and canal irrigated areas located along with river Godavari and Girna are shows water depth near to the surface. Very Small northeastern part (02 per cent) of the district have water table at high level. In intensive cash cropping areas in Godavari and Girna river basin have observed groundwater at medium to low level.

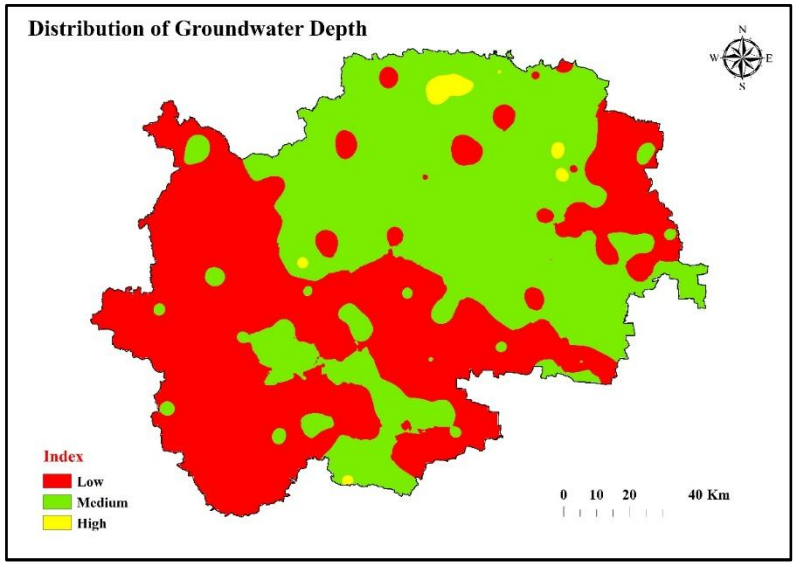

Fig. no. 4: Distribution of groundwater depth

Fluctuations in Groundwater:

Low fluctuations in groundwater table is observed in the areas having high rainfall in western part, irrigation facility along with river Godavari and in the vicinity of irrigation tank near Nashik (figure no.5) contours about 42 per cent TGA (table 1). Whereas comparatively high fluctuations are shows in moderate to low rainfall zone located in and central north-eastern part of the district (07 per cent). Central and eastern part of the district is showing medium fluctuations (51 per cent) in groundwater level.

Table no. 1: Distribution area according to groundwater depth and fluctuations

Class	Depth in %	Fluctuations in %
Low	48	42
Medium	50	51
High	02	07

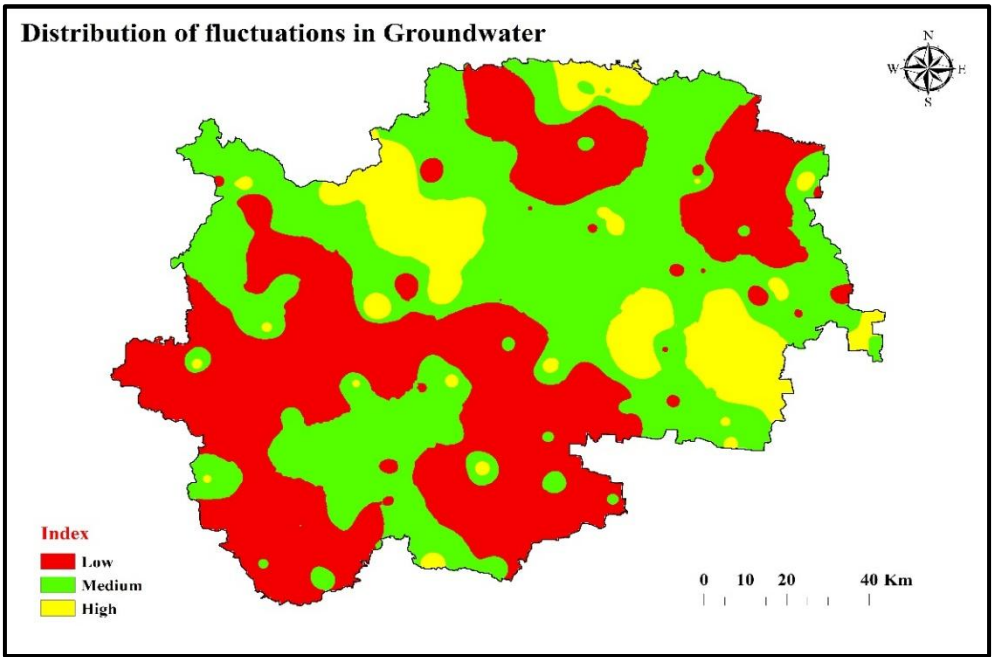

Fig. no. 5: Distribution of Fluctuations in Groundwater

Groundwater utility status areas (GUSA):

The class, MH is showing medium depth and high fluctuations indicating medium groundwater resource with high irrigation insecurity distributed in western part of the district (figure no. 6) covered 1.64 per cent of TGA (table 2). Exploited groundwater with low fluctuations (HL) is observed in areas with high rainfall located in western part and irrigated zones along with river Darna river which area 4.16 per cent is practicing cash crops.

Godavari basin is showing medium groundwater resource with moderate irrigation security (MM) covering about 23.44 per cent of TGA. Good groundwater resource with moderate irrigation security (ML) which area 28.54 and moderate secure groundwater resource (LM) which is area 42.20 distributed along with river in upper Godavari, Girna and Mousam river basin in the district.

It is recommended to the planners and farmers to manage the water resource to agriculture with groundwater utility status. It is more beneficial to the farmers to arrange there cropping pattern with understanding of groundwater availability and irrigation security. For this, the classification and identification of GUSA will become more powerful and useful tool.

Table no. 2: Distribution of GUSA

Utility Class	Area		Remarks
	Hector	%	
MH	25446	1.64	Medium depth and high fluctuations medium groundwater resource with high irrigation insecurity.
HL	64564	4.16	Exploited groundwater with low fluctuations.
MM	363151	23.44	Medium groundwater resource with moderate irrigation security.
LM	653721	42.20	Good groundwater resource with moderate irrigation security.
ML	442124	28.54	Moderate secure groundwater resource
Total	1549007	100	Estimated area in GIS

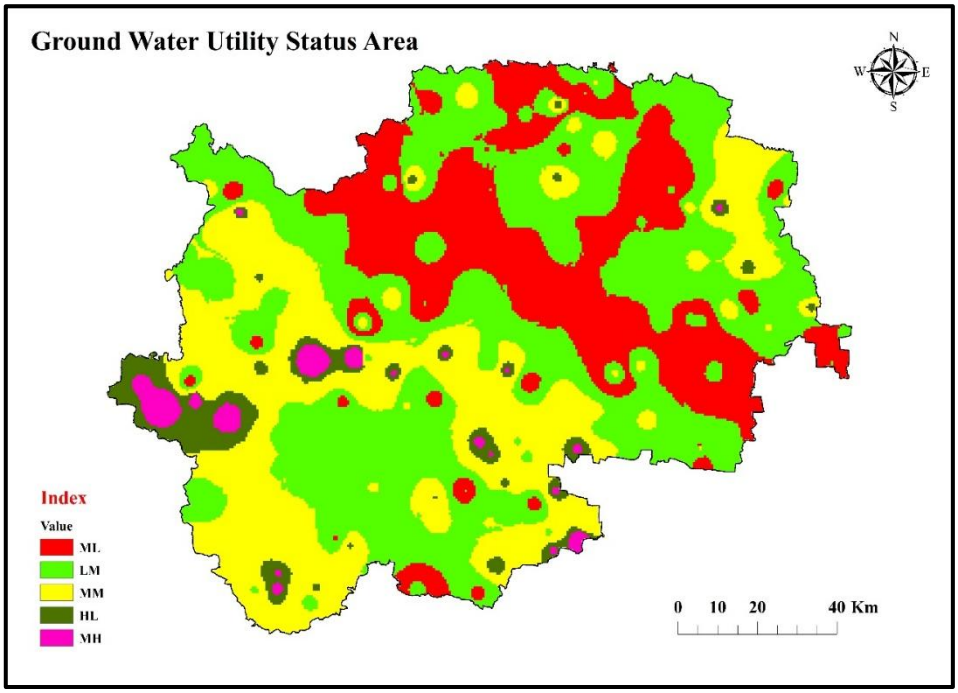

Fig. no. 6: Groundwater Utility Status Areas

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